SOLAR/1017-79/01

Monthly Performance Report

FACILITIES DEVELOPMENT

JANUARY 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

MONTHLY PERFORMANCE REPORT

FACILITIES DEVELOPMENT GAS COMPANY

JANUARY 1979

I. SYSTEM DESCRIPTION

The Facilities Development Gas Company site is a three-story, multifamily condominium consisting of 31 units in San Diego, California. Solar energy is used for preheating domestic hot water (DHW) for the complex. The solar energy system has an array of flat-plate collectors with a gross area of 520 square feet. The array faces south at an angle of 42 degrees to the horizontal. Potable water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in an insulated 1000-gallon glass-lined tank. Preheated water from the storage tank is supplied, on demand, to 31 conventional 52-gallon DHW tanks. When solar energy is insufficient to satisfy the hot water load, two electrical heating elements, energized separately within the individual DHW tanks, provide auxiliary energy for water heating. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when the water temperature in the collectors is 9°F higher than the temperature of the storage tank. Water is pumped through the collectors and circulates back to storage until the temperature difference is 3°F or less.

Mode 2 - Storage-to-DHW Tank: This mode activates when there is a demand for hot water replenishment by the individual DHW tank. Water from storage circulates by thermosiphoning action through a supply service loop to the individual DHW tanks and returns through a service line to storage. The water in each DHW tank is maintained at an average temperature which is thermostatically controlled. When required, additional energy is supplied by an electrical auxiliary element.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in January and the solar energy system operated continuously during the month. Solar energy satisfied 13 percent of the DHW requirements. The solar energy system provided electrical energy savings of 6.2 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 18.4 million Btu for a daily average of 1143 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area

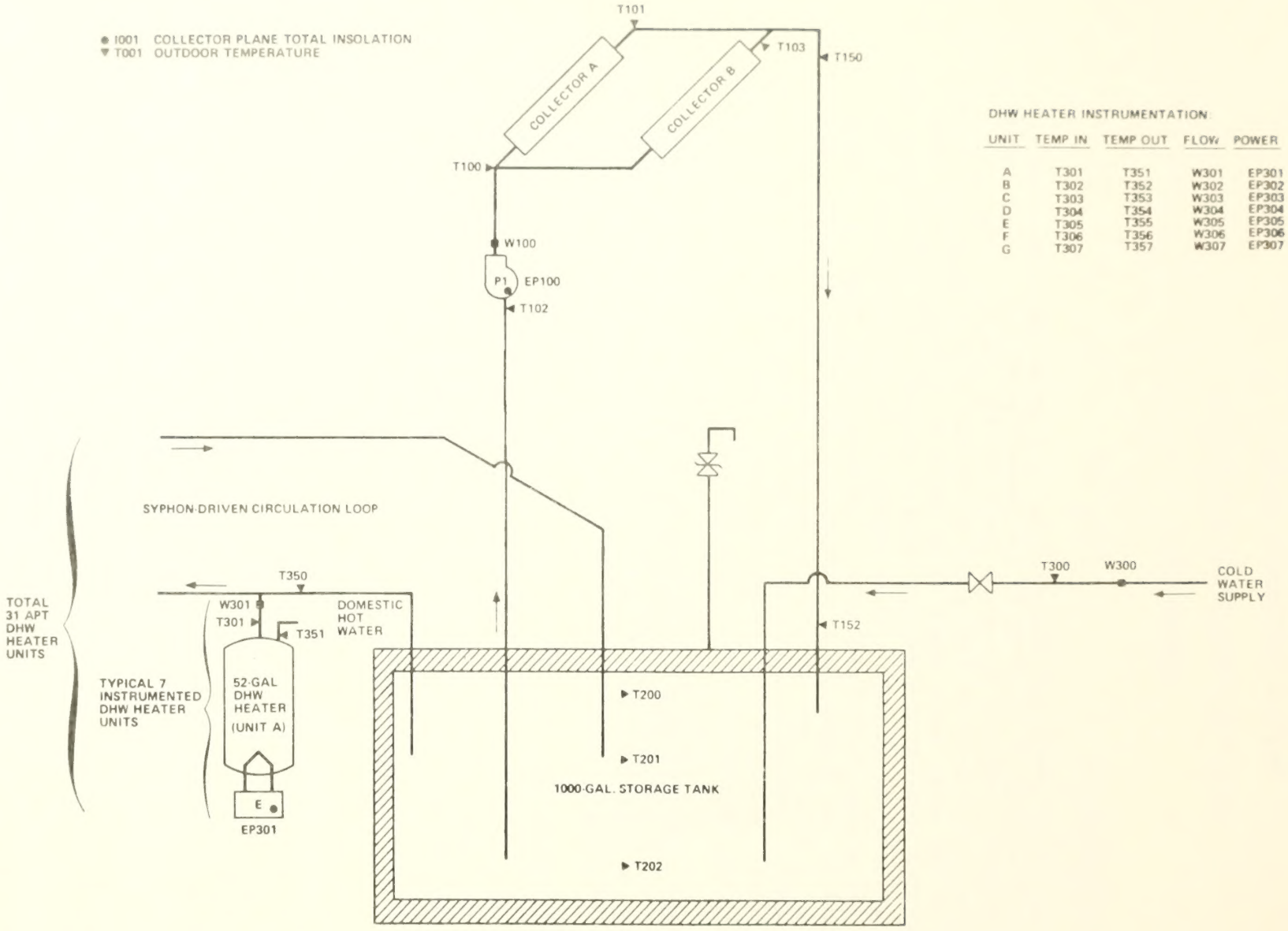

Figure 1. FACILITIES DEVELOPMENT SOLAR ENERGY SYSTEM SCHEMATIC

during January of 1571 Btu per square foot for a south-facing plane with a tilt of 42 degrees to the horizontal. The average ambient temperature during January was 53°F as compared with the long-term average for January of 55°F. The number of heating degree-days for the month (based on a 65°F reference) was 364, as compared with the long-term average of 314. The number of cooling degree-days was zero, as compared with the average of 10.

THERMAL PERFORMANCE

System - During January the solar energy system performed approximately the same as expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 7.5 million Btu versus an estimated 7.2 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 6.4 million Btu. System total solar fraction was 13 percent versus an estimated 15 percent.

Collector - The total incident solar radiation on the collector array for the month of January was 18.4 million Btu. During the period the collector loop was operating, the total insolation amounted to 15.6 million Btu. The total collected solar energy for the month of January was 7.5 million Btu, resulting in a collector array efficiency of 41 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 6.9 million Btu. Energy loss during transfer from the collector array to storage was 0.66 million Btu. This loss represented 9 percent of the energy collected. Operating energy required by the collector loop was 0.18 million Btu.

Storage - Solar energy delivered to storage was 6.9 million Btu. There were 6.4 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 0.90 million Btu. This loss represented 13 percent of the energy delivered to storage. The storage efficiency was 87 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 90°F.

DHW Load - The DHW subsystem consumed 6.4 million Btu of solar energy and 42.4 million Btu of auxiliary electrical energy. The solar fraction of this load was 13 percent. The hot water load was not determined. The DHW subsystem resulted in an electrical energy savings of 6.4 million Btu. A daily average of 749 gallons of DHW was consumed.

OBSERVATIONS

The collected solar energy, the collector loop operating energy, energy delivered to storage, solar energy used, and hot water consumed, were derived from overall solar energy system parameters. The auxiliary electrical energy used (representing the entire building) was extrapolated from the averages of seven instrumented apartment units.

The hot water load and the average value of the hot water temperature supplied to the building has not been determined because of inadequate instrumentation.

ENERGY SAVINGS

The solar energy system provided a total electrical energy savings of 6.2 million Btu.

III. ACTION STATUS

No action is required at this time.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY — SOLAR/1017-79/01
REPORT PERIOD: JANUARY, 1979

SITE/SYSTEM DESCRIPTION:
THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTRUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 520 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BURIED.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	18.432 MILLION BTU
	35446 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	7.518 MILLION BTU
	14458 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	53 DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.35
ECSS OPERATING ENERGY	0.181 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.181 MILLION BTU
TOTAL ENERGY CONSUMED	50.091 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	N.A.	N.A.	N.A.	N.A.	MILLION BTU
SOLAR FRACTION	N.A.	N.A.	N.A.	N.A.	PERCENT
SOLAR ENERGY USED	6.410	N.A.	N.A.	6.410	MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	0.181	MILLION BTU
AUX. THERMAL ENERGY	42.392	N.A.	N.A.	42.792	MILLION BTU
AUX. ELECTRIC FUEL	42.392	N.A.	N.A.	42.392	MILLION BTU
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A.	MILLION BTU
ELECTRICAL SAVINGS	6.410	N.A.	N.A.	6.230	MILLION BTU
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A.	MILLION BTU

SYSTEM PERFORMANCE FACTOR: *

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JANUARY,1979

SITE/SYSTEM DESCRIPTION:
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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	19.446 GIGA JOULES
	402525 KJ/SQ.M.
COLLECTED SOLAR ENERGY	7.932 GIGA JOULES
	164183 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	12 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.35
ECSS OPERATING ENERGY	0.191 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.191 GIGA JOULES
TOTAL ENERGY CONSUMED	52.846 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	N.A.	N.A.	N.A. GIGA JOULES
SOLAR FRACTION	N.A.	N.A.	N.A.	N.A. PERCENT
SOLAR ENERGY USED	6.763	N.A.	N.A.	6.763 GIGA JOULES
OPERATING ENERGY	N.A.	N.A.	N.A.	0.191 GIGA JOULES
AUX. THERMAL ENG	44.723	N.A.	N.A.	44.723 GIGA JOULES
AUX. ELECTRIC FUEL	44.723	N.A.	N.A.	44.723 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
ELECTRICAL SAVINGS	6.763	N.A.	N.A.	6.573 GIGA JOULES
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. GIGA JOULES

SYSTEM PERFORMANCE FACTOR: *

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JANUARY,1979

SOLAR/1017-79/01

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.945	49	0.162	N	0.008	N	0.172
2	0.563	50	0.178	O	0.006	O	0.317
3	0.564	55	0.286	T	0.008	T	0.431
4	0.856	54	0.192		0.008		0.224
5	0.367	59	0.246	A	0.004	A	0.679
6	0.446	59	0.151	P	0.005	P	0.339
7	0.671	57	0.175	P	0.007	P	0.261
8	0.858	55	0.212	L	0.008	L	0.247
9	0.130	55	0.232	I	0.001	I	1.782
10	0.882	53	0.175	C	0.009	C	0.199
11	0.677	55	0.267	A	0.007	A	0.394
12	0.450	58	0.205	B	0.007	B	0.457
13	0.737	55	0.232	L	0.007	L	0.315
14	0.359	54	0.220	E	0.004	E	0.613
15	0.080	55	0.153		0.001		1.909
16	0.200	58	0.089		0.006		0.444
17	0.543	56	0.142		0.007		0.261
18	0.646	53	0.197		0.006		0.305
19	0.989	51	0.205		0.009		0.207
20	0.761	51	0.301		0.007		0.395
21	0.385	54	0.262		0.003		0.681
22	0.570	52	0.294		0.006		0.508
23	0.831	53	0.198		0.007		0.238
24	0.090	53	0.230		0.000		2.550
25	0.552	53	0.109		0.005		0.197
26	1.043	50	0.219		0.009		0.210
27	1.047	49	0.264		0.009		0.252
28	0.575	50	0.285		0.004		0.496
29	0.860	44	0.207		0.007		0.240
30	0.480	50	0.188		0.004		0.391
31	0.170	53	0.125		0.002		0.736
SUM	18.432	-	6.410	N.A.	0.181	N.A.	-
AVG	0.595	53	0.207	N.A.	0.006	N.A.	0.348
NBS ID	0001	N113			0102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SOLAR/1017-79/01
REPORT PERIOD: JANUARY, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.945	0.850	0.348	61	0.369
2	0.563	0.453	0.171	60	0.304
3	0.664	0.614	0.315	66	0.474
4	0.856	0.797	0.357	66	0.417
5	0.363	0.301	0.128	62	0.352
6	0.446	0.363	0.169	61	0.378
7	0.671	0.616	0.308	63	0.460
8	0.858	0.802	0.380	61	0.443
9	0.130	0.079	0.022	57	0.165
10	0.882	0.842	0.402	61	0.479
11	0.677	0.588	0.282	60	0.417
12	0.450	0.406	0.194	60	0.431
13	0.737	0.644	0.322	63	0.437
14	0.359	0.256	0.117	60	0.325
15	0.080	0.025	0.014	59	0.178
16	0.200	0.169	0.096	63	0.478
17	0.543	0.500	0.257	59	0.474
18	0.646	0.601	0.301	58	0.466
19	0.989	0.920	0.417	60	0.422
20	0.761	0.654	0.287	61	0.377
21	0.385	0.151	0.133	61	0.345
22	0.579	0.462	0.254	59	0.438
23	0.831	0.748	0.406	61	0.488
24	0.000	0.000	0.000	57	0.000
25	0.552	0.412	0.245	55	0.444
26	1.043	0.973	0.473	57	0.453
27	1.047	0.932	0.409	59	0.391
28	0.575	0.349	0.160	53	0.278
29	0.860	0.723	0.299	54	0.347
30	0.480	0.364	0.175	56	0.365
31	0.170	0.092	0.057	54	0.338
SUM	18.432	15.647	7.518	-	-
AVG	0.595	0.505	0.243	60	0.408
NBSID	0001		0100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SOLAR/1017-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.335	0.162	-0.104	102	0.173
2	0.160	0.178	-0.090	100	0.554
3	0.306	0.286	-0.020	97	0.869
4	0.352	0.192	0.074	101	0.754
5	0.126	0.246	-0.102	95	1.143
6	0.115	0.151	-0.051	88	0.875
7	0.252	0.175	0.047	91	0.879
8	0.339	0.212	0.087	98	0.882
9	0.028	0.232	-0.212	84	0.707
10	0.405	0.175	0.180	89	0.877
11	0.257	0.267	-0.010	98	0.998
12	0.184	0.205	-0.030	92	0.953
13	0.306	0.232	0.031	97	0.860
14	0.114	0.220	-0.104	91	1.020
15	0.018	0.183	-0.111	75	2.338
16	0.095	0.089	0.015	71	1.095
17	0.237	0.142	0.094	79	0.993
18	0.277	0.197	0.048	89	0.887
19	0.388	0.205	0.122	99	0.841
20	0.252	0.301	-0.066	101	0.931
21	0.114	0.262	-0.101	91	1.408
22	0.240	0.294	-0.002	85	1.220
23	0.379	0.198	0.099	91	0.783
24	0.002	0.239	-0.239	80	0.004
25	0.224	0.109	0.102	73	0.941
26	0.433	0.219	0.170	94	0.899
27	0.328	0.264	0.071	104	0.896
28	0.128	0.285	-0.166	96	0.926
29	0.241	0.207	0.037	88	1.012
30	0.166	0.188	-0.051	84	0.820
31	0.053	0.125	-0.134	71	-0.171
SUM	6.856	6.410	-0.458	-	-
AVG	0.221	0.207	-0.015	90	0.868
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: FACILITIES DEVELOPMENT GAS COMPANY — FD_A9/1017-79/01
REPORT PERIOD: JANUARY,1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	N	N	0.162	N	0.945	0.945	N	0.162	N	61	N	442
2	O	O	0.178	C	1.378	1.378	O	0.178	O	60	O	329
3	T	T	0.286	T	1.511	1.511	T	0.286	T	59	T	807
4			0.192		1.415	1.415		0.192		58		565
5	A	A	0.246	A	1.231	1.231	A	0.246	A	60	A	615
6	P	P	0.151	P	0.873	0.873	P	0.151	P	61	P	774
7	P	P	0.175	P	1.329	1.329	P	0.175	P	60	P	570
8	L	L	0.212	L	1.408	1.408	L	0.212	L	59	L	604
9	I	I	0.232	I	1.276	1.276	I	0.232	I	58	I	800
10	C	C	0.175	C	1.540	1.540	C	0.175	C	60	C	771
11	A	A	0.267	A	1.706	1.706	A	0.267	A	59	A	804
12	B	B	0.205	B	1.064	1.064	B	0.205	B	61	B	633
13	L	L	0.232	L	1.204	1.204	L	0.232	L	59	L	675
14	E	E	0.220	E	0.821	0.821	E	0.220	E	59	E	740
15			0.153		1.593	1.593		0.153		60		796
16			0.089		1.759	1.759		0.089		60		342
17			0.142		1.512	1.512		0.142		58		719
18			0.197		1.472	1.472		0.197		58		685
19			0.205		1.241	1.241		0.205		60		572
20			0.301		1.461	1.461		0.301		59		820
21			0.262		1.431	1.431		0.262		60		926
22			0.294		1.480	1.480		0.294		59		1027
23			0.198		0.894	0.894		0.198		59		657
24			0.239		1.305	1.305		0.239		59		822
25			0.109		1.427	1.427		0.109		60		734
26			0.219		1.178	1.178		0.219		60		777
27			0.264		0.972	0.972		0.264		60		711
28			0.285		1.318	1.318		0.285		59		813
29			0.207		1.934	1.934		0.207		58		898
30			0.188		1.650	1.650		0.188		59		794
31			0.125		2.064	2.064		0.125		59		1031
SUM	N.A.	-	6.410	N.A.	42.392	42.392	N.A.	6.410	N.A.	-	-	23203
AVG	N.A.	N.A.	0.207	N.A.	1.367	1.367	N.A.	0.207	N.A.	59	N.A.	749
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q312	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JANUARY,1979

SOLAR/1017-79/01

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1817	N	49	61	N	N	N
2	1083	O	50	60	O	O	O
3	1278	T	55	66	T	T	T
4	1647		54	66			
5	698	A	59	69	A	A	A
6	858	P	59	61	P	P	P
7	1290	P	57	63	P	P	P
8	1650	L	55	61	L	L	-
9	250	I	55	57	I	I	I
10	1696	C	53	61	C	C	C
11	1302	A	55	60	A	A	A
12	354	B	58	60	B	B	B
13	1417	L	55	53		L	-
14	590	E	54	60	E	E	E
15	154		55	59			
16	385		58	63			
17	1044		56	59			
18	1242		53	58			
19	1901		51	60			
20	1454		51	61			
21	740		54	61			
22	1113		52	59			
23	1598		53	61			
24	173		53	57			
25	1062		53	55			
26	2006		50	57			
27	2013		49	59			
28	1106		50	57			
29	1554		44	54			
30	923		50	56			
31	327		53	54			
SUM	35446	N.A.	-	-	-	-	-
AVG	1143	N.A.	53	60	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

☆ U.S. G.P O. 1979—640-189/4143